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QT Interval Changes in Moderate and Severe Brain Injuries

Saied Abrishamkar, MD,* Salman Abbasi Fard, MD,* Ali Momeni, MD,†
Abdol_Razagh Irii, MD,* and Mersedeh Rohanizadegan, MD‡

Backgrounds: Traumatic brain injuries are common mortality causes in many countries. Electrocardiogram (ECG) changes after brain injuries are known, and among them alteration of QT interval is common. The aim of this study was to evaluate QT interval changes in patients suffering from moderate-to-severe brain injuries.

Methods: In a descriptive analytical study with 2 retrospective and prospective components, we first evaluated 200 files of patients with moderate-to-severe brain damage who were admitted in Kashani and Alzahra hospitals from 2003 to 2005. Second, 39 patients with moderate-to-severe brain damage admitted at the same hospitals after 2005 were observed for 3 consecutive days by performing serial ECGs.

Results: Retrospective study: From the total of 200 patients, 117 were male and 83 were female. There was no statistically significant relationship between sex and computed tomography scan lesions ($P > 0.05$). The mean QT interval in patients who subsequently died was longer, which was statistically significant ($P < 0.05$). A total of 119 patients had prolonged QT interval in the first ECG. Prospective study: From the total of 39 patients, 23 were male and 16 were female. Mean QT intervals in the first, second, and third days were 461, 459, and 453 ms, respectively. They decreased significantly in those undergoing another surgery by the second and third day after the first surgery ($P < 0.05$).

Conclusions: It is obvious from this study that in patients with brain injuries QT interval is prolonged and this prolongation has a significant relationship with the Glasgow Coma Scale score and mortality rate. Female patients were more likely to have a prolonged QT interval after brain injury.

Key Words: head injury, QT interval, Glasgow coma scale

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Traumatic head injuries are an important cause of death in many countries and the increasing use of imaging technology has highlighted their role in mortality after trauma. Accidents are the major cause of traumatic

head injuries.¹ One of the important factors affecting the outcome of head trauma is cardiac arrhythmia.² Arrhythmias usually develop as a result of myocardial injury, but it has been noted that neurological factors can induce arrhythmia in a healthy heart. In particular, ventricular arrhythmias are an important cause of death in central nervous system injuries.³ An association between cardiac arrhythmias and cerebral injuries has been mentioned for years and various types of electrocardiogram (ECG) changes have been reported in cerebral trauma, such as alternation in cardiac cyclic rhythm, bradycardia, tachycardia, shortening or elongation of QT interval, ST segment changes, inverted T wave, and U wave.^{2–5} Among these, prolonged QT interval is of paramount importance because it can lead to torsade de pointe, which is a fatal arrhythmia.⁶

In our country, head trauma after accidents is a common health problem and identification of mortality and disability factors in these patients is critical. We designed this study to evaluate the role of moderate and severe trauma in ECG changes, especially prolongation of the QT interval, which may predict a life-threatening arrhythmia. This event could also be the cause of death in some of our patients in the absence of obvious causes of death associated with the intracranial pathology.

METHODS

We designed an observational study consisting of 2 parts: retrospective and prospective. In the retrospective section, we collected data pertaining to 200 patients with moderate-to-severe head trauma who had been admitted to Isfahan Ayatollah Kashani and Alzahra hospitals between March 2003 and December 2005. For all the patients, ECG and level of consciousness at the time of recording ECG, age, sex, renal function indices, brain computed tomography (CT) scan report, and mortality were recorded from their hospital files. Exclusion criteria were the following: age less than 1 year or more than 50 years, history of cardiovascular diseases, history of renal diseases or decreased renal function indices, mild head trauma, brain death, and vegetative state, as well as history of receiving cardiac or antiarrhythmic medication. All patients had an ECG with 12 leads (6 limb leads and 6 precordial leads) and their QT intervals were calculated and corrected on the basis of the Bazett formula.^{7,8} We measured the QT intervals in II, V5, and V6 leads and considered their average as the patient's QT interval.⁷

From the *Department of Neurosurgery, Isfahan University of Medical Sciences, Isfahan; †Department of Internal Medicine, Shahrekord University of Medical Sciences, Shahrekord; and ‡Research Department, Farzan Clinical Research Institute, Tehran, Iran.

The authors declare no conflict of interest.

Reprints: Salman Abbasi Fard, MD, Neurosurgery Department, Al-Zahra Hospital, Isfahan University of Medical Sciences, Isfahan, Iran (e-mail: Dr_abbasi_s@yahoo.com).

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One of the important problems in determining QT interval is finding the exact point at which the descending arm of the T wave crosses the isoelectric line, especially in the presence of a U wave. To overcome this concern we observed the following rule: when there is no U wave or U and T waves are clearly separated, the end of the T wave is the point at which the descending arm of the T wave crosses the isoelectric line; when the T wave is biphasic, the end of the T wave is considered as the ultimate point; when the T wave and U wave are not separated, the end of the U wave is considered the end point. To distinguish T and U waves, we noted that biphasic T waves repeat in several leads of ECG but the U wave is a small wave that is constant in lateral and precordial leads.

The Glasgow Coma Scale score (GCS) was used for determining the level of consciousness of patients.⁹ GCS = 13 to 15 was regarded as mild head trauma; GCS = 9 to 12 was regarded as moderate head trauma; and GCS = 3 to 8 was regarded as severe head trauma. The injuries that were seen in the brain CT scan of patients included the following: diffuse axonal injury, subarachnoid hemorrhage (SAH), subdural hematoma (SDH), epidural hematoma (EDH), and intracranial hemorrhage.

Information obtained from the retrospective study had some defects. For example, the patients had undergone no serial ECGs, intervals between the patients' ECGs were different, or we did not have ECGs from both before and after surgery. Because of the problems accruing from incomplete patient files, we decided to conduct a prospective study. Thirty-nine patients with moderate-to-severe head trauma who were admitted to Isfahan Ayatollah Kashani and Alzahra hospitals after December 2005 were included in the prospective study. Brain CT scan was performed for each of these patients. Serum electrolytes (Na, K) and renal function indices (BUN, Cr) were also measured. Each patient had ECGs recorded in a sequence of 3 days: the first one was taken before surgery (if any was performed) and the other 2 after surgery (if performed). Our exclusion criteria were the following: age less than 1 year or more than 50 years, serum electrolyte disturbance, altered renal function indices, history of cardiovascular or renal diseases, and brain death. The QT interval according to the Bazett formula, daily patient GCS, brain CT scan report, surgery if performed, and patient mortality were documented.

We confirmed again that our study protocol was approved by Ethics Committee Of Isfahan University of Medical Sciences and Informed Consent was obtained from the patients enrolled in the prospective part of the study, or from their representatives, whichever was appropriate. The data were analyzed with independent samples using the *t* test and χ^2 tests. The descriptive data were

summarized as frequencies, means, and SD. *P*-value of 0.05 was considered as the cutoff point for statistical significance.

RESULTS

Retrospective Study

A total of 200 patients were included in the retrospective study; 117 (58.5%) were male and 83 (41.5%) were female. There was no statistically significant relationship between sex and pathologic lesions in brain CT scan (*P* > 0.05). The percentage of each brain CT scan lesion is shown in Table 1.

Of the total number of patients, 138 (69%) underwent surgery. All patients with SDH-SAH or SDH on CT scan were operated upon. The frequency of surgery in patients with intracranial hemorrhage-SDH and EDH-SAH was 96% and 95%, respectively, and none of the patients with isolated diffuse axonal injury and SAH underwent surgery. There was a statistically significant relationship between lesion type in CT scan and performance of surgery as shown (*P* < 0.05).

Mortality was recorded in 36 patients (18%), most of whom had SAH. Of a total of 18 patients with SAH, 6 (33%) died during our investigation, but there was no statistically significant relationship between the type of cerebral lesion and mortality rate (*P* = 0.346).

We analyzed the correlation between 3 GCS scores (determined at the time of executing the 3 steps of ECGs) and between QT intervals of 3 available ECGs. Only the first and second GCSs, the second and third GCSs, and the first and second QT intervals were significantly correlated (*P* < 0.05). Table 2 shows the mean of QT intervals in ECGs and the mean of GCSs of alive and deceased patients.

Of 200 patients, 119 had prolonged QT interval in ECGs; 79 were male and 40 were female. The mean of prolonged QT interval was 486 ms in male patients and 496 ms in female patients. In the evaluation of the QT interval of the 2 sexes there was no relationship between sex and QT interval duration (*P* > 0.05), but there was a statically significant relationship between female sex and prolongation of QT interval (*P* < 0.01). Each QT interval had an inverse relation with the GCS of the patient at the time of recording the ECG, and these relationships were statistically significant (*P* < 0.05). There was no association between age and QT interval or between age and GCS or age and CT scan lesion type (*P* > 0.05). We detect no relationship between prolongation of QT interval in the first ECG and the lesion type (*P* > 0.05).

TABLE 1. Percentage of Brain CT Scans Lesions in the Retrospective Section of the Study

Lesion Type	DAI	EDH-SAH	EDH	ICH-EDH	ICH-SAH	ICH-SDH	ICH	SAH-SDH	SAH	SDH
Percentage	6.5%	6.5%	12.5%	7%	0.5%	14.5%	20.5%	10.5%	9%	12.5%

CT indicates computed tomography; DAI, diffuse axonal injury; EDH, epidural hematoma; ICH, intracranial hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hematoma.

TABLE 2. Mean of QT Intervals in Milliseconds and the Mean of GCSs of Alive and Dead Patients

	Mortality	No. Patients	Mean	P
First ECG	Dead	36	482	0.004
	Alive	164	463	
Second ECG	Dead	6	485	0.977
	Alive	32	471	
Third ECG	Dead	1	482	0
	Alive	8	465	
First GCS	Dead	36	7-8	0.386
	Alive	164	9-10	
Second GCS	Dead	6	6-7	0.231
	Alive	32	10-11	
Third GCS	Dead	1	9	0
	Alive	8	10-11	

ECG indicates electrocardiogram; GCS, the Glasgow Coma Scale score.

Prospective Study

Thirty-nine patients were included; 59% were male and 41% were female. Twenty-eight (71.8%) patients underwent surgery. SDH and EDH were the most common lesions in brain CT scans of operated patients and included 23.1% and 20.5% of CT scan abnormalities, respectively. The average duration of QT interval in ECGs of the first, second, and third days was 461, 459, and 453 ms, respectively, and the time-related reduction was statistically significant ($P < 0.05$). QT interval prolongation was significantly larger in female patients ($P < 0.05$). The average GCS score in these 3 (first, second, and third) consecutive days was 8 to 9, 9 to 10, and 9 to 10, respectively.

We separated the patients according to their QT interval duration into the following groups: borderline (male < 430 , female < 450), normal (male = 431 to 450, female = 451 to 470), and prolonged (male > 450 , female > 470). In the first, second, and third ECGs, we had 61.5%, 59%, and 51% prolonged QT interval, respectively. QT interval duration and GCS of each day had a statistically significant relationship, whereas increase in GCS led to a decrease in QT interval ($P < 0.05$).

DISCUSSION

Our findings indicate that QT prolongation is frequently observed in moderate and severe head injuries, (119 of 200 patients in our study). This is consistent with Burch et al's² study on SAH patients, in which the authors reported a large percentage of QT interval changes. Collier et al¹⁰ inspected traumatic SAH patients and discovered that QT interval had been increased significantly in comparison with the control group. Prolongation of QT interval has also been reported in children with severe traumatic head injury.¹¹

We noted higher durations of QT interval in female patients both in our retrospective and prospective studies. This finding has been mentioned in previous studies but its mechanism is unknown. Drici et al¹² have noted that ovariectomy in rabbits decreases the QT interval duration and high doses of sexual hormones could increase the

QT interval duration. Other studies claim that sexual hormones in healthy women have no effect on QT interval.^{13,14} Another mechanism that is possibly related to sex difference of QT interval duration is the cellular structure of the heart between male and female patients, which might lead to more susceptibility to hypokalemia and therefore to QT interval elongation in female patients.¹⁵

We showed that QT interval duration decreases after surgery in ECGs of the second and third day after operation, and its reduction was statistically significant. We also noted that the average duration of QT interval was significantly higher in patients who died, but their GCS scores were lower. We propose that all the patients with head trauma, especially those who had lower GCS after admission, should be screened using serial ECGs or cardiac monitoring to detect ECG changes and to ensure a suitable prevention of potentially fatal arrhythmias.

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